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Development, feasibility, acceptability, and adjustment of a portable, multifactorial falls risk test battery for community-dwelling older adults.

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Abstract: Purpose: Falls accidents are common in older adults and may have severe consequences. Targeting prevention requires accurate, feasible, and time-efficient falls prediction. Aim: To develop, evaluate, and adjust a portable multifactorial test battery for falls risk prediction in community-dwelling older adults. **Materials and Methods**: Through a multidisciplinary consensus meeting, we developed a preliminary test battery to be completed in a 35-minutes time frame. Risk factors exceeding the time frame were included in a self-reported questionnaire. Eight participants (≥75 years) were tested. Time spent was recorded and tests were evaluated by interviews. Adjustments were made through a modified nominal group technique based on scientific validity, time spent, and evaluations. Questionnaire items were discussed and adjusted. **Results**: The preliminary test battery was not feasible. Content was adjusted based on assessment of feasibility and acceptability of tests. The final test battery consisted of gait speed, grip- and leg strength, leg reaction time, and dual-task balance (measured using the Nintendo Wii Balance Board), arrhythmia screening, and Orientation-Memory-Concentration test. The questionnaire included the Tilburg Frailty Indicator, Mini-Nutritional-Assessment, Vulnerable Elders Survey-13, Short Falls Efficacy Scale-International, EuroQol-5-Dimension-3-Level, Geriatric Depression Scale, and single risk factors. **Conclusion**: An iterative development process with consensus meetings

ABOUT THE AUTHOR

The research activities of our group are focused on falls prevention. Through the years, we have validated novel, portable low-cost technologies for assessing risk factors for falls. More specifically, it involves using the Nintendo Wii Balance Board, originally intended for gaming, as a measuring device for strength, balance and reaction time. Also, our research group is working closely with primary care in conducting scientifically sound and implementable research for clinical practice. The research in this study is a product of this collaboration that has generated a list of well-known falls risk factors implementable for clinical practice. This list may be used for identification of individuals with high risk of falling that would benefit from falls prevention interventions. Thus, we are currently performing a prospective cohort study with the purpose of predicting who is at risk of falling.

PUBLIC INTEREST STATEMENT

Falls in older adults are a common problem having severe consequences such as increased risk of fractures, poorer physical functioning, and death. Falls may be prevented by treating individuals at high risk of falling. In order to identify these, screening for known falls risk factors is necessary. Unfortunately, more than 400 falls risk factors exist, screening procedures may be expensive if too time consuming, and some risk factors may be impractical to test for. Our study aimed to make a prioritised list of risk factors for screening older adults' falls risk. The list comprised relevant risk factors that were quick to test for, used portable testing equipment to perform tests at home, and were well liked by older adults together with personnel having to perform the screening procedures. We are currently testing the risk factors in a new study to see if they identify older adults at high risk of falling.

and feasibility testing was used to develop a multifactorial test battery designed to predict falls in an older community-dwelling population.

Subjects: Aging; Research methods; General Medicine; Medical Technology & Engineering

Keywords: accidental falls; independent living; aged; risk assessment; consensus; primary prevention

1. Introduction

Internationally, falls in community-dwelling older adults are frequent with an annual incidence of 30% and 50% in adults over 65 and 80 years of age, respectively (World Health Organization [ACS], 2007). The falls burden is expected to increase markedly with an ageing population (United Nations, Department of Economic and Social Affairs PD, 2017). Falls are associated with increased morbidity, mortality, poor physical function, and early admission to long-term care facilities (Cummings-Vaughn & Gammack, 2011; Juel, Sørensen, & Brønnum-Hansen, 2008; Rubenstein, 2006). The problem of falls is of major concern to society and thus falls prevention has become a high priority.

In order to prevent future falls, older adults at high risk of falling need to be identified early and efficiently. However, this is not an easy task. Several attempts have been made on this issue using multifactorial prediction models, but with moderate success as only 60-70% have been correctly classified as fallers or non-fallers (Hnizdo, Archuleta, Taylor, & Kim, 2013; Lamb, McCabe, Becker, Fried, & Guralnik, 2008; Obrist, Rogan, & Hilfiker, 2016; Rodriguez-Molinero et al., 2017; Stalenhoef, Diederiks, Knottnerus, Kester, & Crebolder, 2002; Tromp et al., 2001; Yamashita, Jeon, Bailer, Nelson, & Mehdizadeh, 2011). A possible reason for this lack of success could be attributed to the fact that more than 400 falls risk factors have been identified (Oliver, 2004). For example, in recent years, the interaction between cognition and mobility has become an area of focus within falls research (Montero-Odasso, Almeida, & Bherer et al., 2018), and impairments in executive function have been associated with falls in a number of studies (Hsu, Nagamatsu, Davis, & Liu-Ambrose, 2012; Muir, Gopaul, & Montero Odasso, 2012). Furthermore, training designed to improve cognitive function has been shown to reduce the number of falls by 54% (Trombetti et al., 2011). Meanwhile, this cognitive/mobility interaction has only seldomly been applied in multifactorial falls prediction models (Buracchio et al., 2011).

With increasing number of falls risk factors being identified, the ability to test for these in everyday practice has become an important issue. Therefore, to ensure applicability, time spent and feasibility within the setting may be relevant components to consider when selecting falls risk factors to test for.

1.1. Objectives

Our objectives were to develop, evaluate, and adjust a portable multifactorial test battery intended for falls risk prediction in community-dwelling older adults. In addition, we wanted a battery that could be completed within 35 minutes and brought into people's own homes.

2. Materials and methods

2.1. Overall description of stages in the development of the test battery

The developmental process of the test battery was divided into different stages. First, we investigated overall requirements for the test battery in the setting. Second, we performed a literature search using the PubMed database to inform the first expert consensus meeting where a preliminary portable, multifactorial test battery was constructed. After the preliminary test battery was decided upon, data collectors received training on the included individual tests. Finally, tests were performed on older citizens and evaluated in order to inform a pre-meeting survey for a

second consensus meeting. Here, the content of the final test battery was decided upon, based on the survey results with individual prioritisations of tests among all attendees. Figure 1 illustrates this process.

2.2. Setting and requirements for the test battery

Our research group made a collaboration agreement with a medium-sized municipality in Northern Jutland, Denmark, who would be responsible for collecting data for the study. In Denmark, municipalities perform preventive initiatives to preserve good health, quality of life, and independence in older adults through, e.g. preventive home visits and at senior activity centres. The target group of preventive home visits is community-dwelling older adults primarily 75+ years old who are consecutively outreached annually by the preventive home visit-unit in the municipality. The target group of senior activity centres is primarily retirees (65+ years old). We were granted 35 minutes per citizen to recruit and test for known falls risk factors. Also, the test battery had to be portable in order to utilise it in preventive home visits. Finally, to achieve successful implementation, the test battery had to be acceptable to both participants and data collectors.

2.3. Literature search

Systematic reviews and primary literature on fall risk factors were found by search in PubMed. These were used to conduct a preliminary list of fall risk factors to be tested with estimates on time consumption according to the literature (see appendix 1).

2.4. First consensus meeting

The first consensus meeting with a multidisciplinary expert panel was held on the 15th of December 2017 at Aalborg University Hospital, Denmark. The purpose of the meeting was to agree on a 35-minute test battery with key falls risk factors, which could be applied in a community setting. To ensure a robust design, the expert panel decided to include risk factors from different domains (physical, psychological, and cognitive). The expert panel consisted of two geriatric medicine professors, two medical doctors, an exercise physiologist, and an external nurse and falls researcher. The latter had not participated in any planning of the study prior to the meeting. Initially, each expert panel member was presented with the preliminary list of falls risk factors found during the literature search. Once the list had been seen by each expert, he/she could add additional risk factors to the list without discussion. Afterwards, each falls risk factor was informally discussed by the expert panel reaching a unanimous agreement on a test battery. Risk factors that were considered too time consuming were excluded, or if possible, included in a self-reported questionnaire together with descriptive characteristics. Individual reasons for not including risk factors were given (see appendix 1).

2.5. Content of test battery

Thirteen falls risk factors were chosen for the test battery at the first consensus meeting. These included measures of grip strength (Blomkvist et al., 2016), unilateral lower extremity strength (Blomkvist, Andersen, de Bruin, & Jorgensen, 2017; Rubenstein, 2006), lower extremity reaction time (Blomkvist, Eika et al., 2017; Delbaere et al., 2010), and dual-task balance (Hsu et al., 2012; Jørgensen, Laessoe, Hendriksen, Nielsen, & Aagaard, 2014; Verghese et al., 2002) using a Nintendo Wii Balance Board and Fysiometer software (Bronderslev, Denmark). Furthermore, the test battery included five days of continuous heart-rate monitoring to screen for arrhythmias (ePatch) (E-patch system, BioTelemetry Inc, Denmark) (Saadi, Fauerskov, & Osmanagic et al., 2013; Sanders et al., 2012), visual acuity and contrast sensitivity using tablet-based software (King Devick Technologies, inc.) (Ivers, Cumming, & Mitchell et al., 1998; Lin et al., 2015), four-metre gait speed test (Quach et

Figure 1. Stages in the development of the test battery

al., 2012), five times sit-to-stand (Tiedemann, Shimada, Sherrington, Murray, & Lord, 2008), and tests of cognition (Muir et al., 2012) using Stroop test a.m. Golden (Golden, 1975), Trail-making-test (Delbaere et al., 2010), and Orientation-Memory-Concentration-test (Wade, 1999). Also, home-hazard evaluations (Rubenstein, 2006) were included by asking the data collector at the preventive home visit to assess lighting conditions and whether the house was unsuitably furnished regarding bed height together with the presence of unstable chairs, missing toilet riser seats, loose carpets, and doorsteps. To ensure compliance with instructions from the Danish working environment authorities, all materials for these tests were transported in a 56-litre, four-wheel suitcase (43 × 70 × 23 cm) with a total weight of 12 kg.

2.6. Content of self-report questionnaire

The self-reported questionnaire included 18 falls risk factors. These were the Tilburg Frailty Indicator (Andreasen, Sørensen, Gobbens, Lund, & Aadahl, 2014), Short Mini-Nutritional-Assessment (Rubenstein, Harker, Salvà, Guigoz, & Vellas, 2001), Vulnerable Elders Survey-13 (Saliba et al., 2001), seven-item Falls Efficacy Scale-International (Kempen et al., 2008), EuroQol-5-Dimension-3-Level (EuroQol Group, 1990), and Geriatric Depression Scale (15-item) (Djernes, Kvist, & Olesen et al., 2004) together with questions on demographic characteristics (Deandrea et al., 2010), falls history (Tinetti, Speechley, & Ginter, 1988), urinary incontinence (Tromp et al., 2001), pain when walking (Leveille et al., 2002), dizziness (Deandrea et al., 2010), most used footwear (Lord & Bashford, 1996), dogs or cats in the household (Pluijm et al., 2006), weekly alcohol consumption (Pluijm et al., 2006), use of multifocal glasses (Lord, Dayhew, & Howland, 2002), home care needs (Hoffman, Hays, & Wallace et al., 2015), falls risk perception (Delbaere, Close, & Brodaty et al., 2010), and use of assistive devices (Deandrea et al., 2010). To ease the process of data collection in this study, diseases (Lawlor, Patel, & Ebrahim, 2003) and medication (Buatois et al., 2010) were not included in the questionnaire.

2.7. Training session

Following the first consensus meeting, a standardised test manual of the test battery was constructed to guide the data collectors (a nurse and a social- and health-care helper). In addition, a full-day training session was held for the data collectors prior to testing any participants. A standard test session would proceed as follows: giving oral participant information, obtaining consent for participation, setting up participants in a data capture tool (Harris et al., 2009), setting up the Fysiometer soft- and hardware, performing the actual tests, and finally filling out the self-report questionnaire. The data collectors were observed and timed by the first author (GVS) during each step in the test sessions with the participants in order to assess the total time spent. Time spent for each step was finally averaged across all observations. Furthermore, the observation of data collectors was done to ensure adherence to the standardised test manual. No statistical reliability assessments were performed since prior studies have shown acceptable reliability for the majority of tests included in the test battery. This is valid for the Fysiometer hardware (Blomkvist, Andersen et al., 2017; Blomkvist et al., 2016; Blomkvist, Eika et al., 2017; Jørgensen et al., 2014), Orientation-Memory-Concentration test (Wade, 1999), four-metre gait speed test (Goldberg & Schepens, 2011), five times sit-to-stand (Bohannon, Shove, Barreca, Masters, & Sigouin, 2007), Trail-making-test (Mitrushina & Satz, 1991), and the ePatch technology (Saadi, Sørensen, & Hansen et al., 2014)

2.8. Participants

Participants for the study were recruited from preventive home visit and in one senior activity centre in the Municipality of Hjorring between the 2nd–27th of March 2018. The data collectors performed recruitment and tests at preventive home visits and the senior activity centre. Data collectors were instructed to include 75+ years old community-dwelling citizens. Participants were excluded if they suffered from acute illness, did not understand Danish, could not follow simple instructions, were unable to stand for 60 seconds unsupported, or diagnosed with dementia. Recruitment from preventive home visits was done consecutively, while participants from the senior activity centre were recruited conveniently.

2.9. Feasibility and evaluations

After the test sessions, both participants and data collectors were interviewed face-to-face by the first author (GVS) about their experiences with the tests using structured interview guides. Each test was summarised using one of the following categories; positive, positive but with comments, or negative. This is illustrated in Figure 2. Following each test, the participants were asked, "Were you able to participate in the test?" and "Was it unpleasant to participate in the test?" If participants were able to participate in the tests and did not find it unpleasant, the evaluation was considered positive. If they were not able to participate in the test, they were asked to state why not, and the evaluation was considered negative. If those able to participate found it unpleasant, they were asked to give reasons. Eventually, these participants were asked, "Would you participate in the test again if you were asked?". If they answered "No", the evaluation was considered negative. If they answered "Yes", the evaluation was considered positive but with comments (Figure 2). All participants' test-evaluations were summarised in an overall evaluation for each test. In addition, data collectors were asked to rate each test in the test battery on the basis of how easy the tests were to perform. This was done on a scale from 1 to 5 with 1 being "Difficult to use" and 5 being "Easy to use". Also, in order to further explore experiences, data collectors were asked to give reasons for their judgement. Tests receiving scores of 1–2, 3, or 4–5 were considered negative, positive but with comments, or positive, respectively. Since the senior activity centre setting was stationary, evaluations on portability was informally discussed only with the data collector at the preventive home visits. The test battery was considered to be feasible and acceptable if all of the following criteria were met: (A) the majority of participants (>75%) were able to complete the physical tests and did not find these unpleasant, (B) both data collectors found tests user-friendly (scoring ≥3), (C) data collectors found the test battery to be portable, and (D) both the recruitment process and actual tests did not exceed 35 minutes.

2.10. Pre-meeting survey and second consensus meeting

The second consensus meeting was held on the 30th of April 2018 at Aalborg University Hospital, Denmark. In order to apply a modified nominal group technique (Murphy, Black, & Lamping, 1998) to

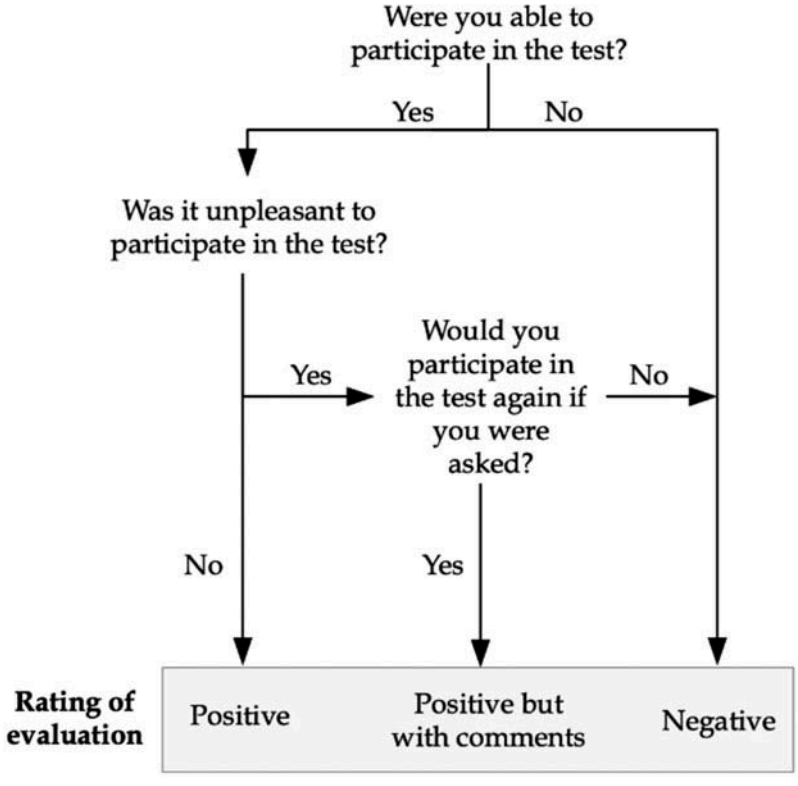

Figure 2. Algorithm for rating participants' evaluations

reach consensus, all evaluations and their comments were forwarded to the expert panel. A pre-meeting survey was completed individually and anonymously by members of the same expert panel prioritising each test based on scientific relevance and recorded time spent together with participants' and data collectors' evaluations. It was a prerequisite for the entire test battery, i.e. tests and self-report questionnaire that it had to be multifactorial by having both physical, cognitive, and psychological fall risk factors present. The external nurse was unable to participate in the second consensus meeting. At the meeting, each priority was converted into ranking scores with the highest priority receiving the score of 1, second highest priority the score of 2, etc. Afterwards, all ranking scores for each test were added up into a total score. Tests were then assembled into a final prioritised list with the lowest total scores having the highest priorities. Finally, cumulative recorded time spent was used to make a cut-off for the number of tests based on the overall time frame. A unanimous level of agreement was aimed for through a subsequent informal discussion of the list of tests. Also, items in the questionnaire were discussed and adjustments were made.

2.11. Ethics

The local Ethics Committee in the Region of North Jutland, Denmark, declared in January 2018 that no specific ethical approval was needed as the study only included non-invasive testing according to the Danish act on the Scientific Ethical Committee System (law no. 593, paragraph 14, subsection 2). Written informed consent was obtained prior to participation after both oral and written information. The study was approved by The Danish Data Protection Agency (number 2018-58-0028) in February 2018.

3. Results

Eight participants were included in the study of which half were women. Mean age was 84.4 years, ranging from 80 to 88 years. At the preventive home visits, seven community-dwelling old adults were consecutively asked and four consented to participate. Reasons for not participating were acute illness, conflicting appointments on the day of the scheduled visit, and refusal to participate in anything involving a doctor. At the senior activity centre, four subjects consented to participation. No missing data on tests were present at the end of the study.

3.1. Time spent and evaluations

Table 1 illustrates the mean recorded time spent for each step in the test session together with evaluations from data collectors. Evaluation summaries are displayed in colours white, light grey, and dark grey representing the categories positive, positive but with comments, and negative, respectively. The scores of the data collectors are also provided. On average, test sessions lasted 66 minutes in total. Of this, an average of 16 minutes was used for giving study information and obtaining consent along with setting up and 50 minutes for actual testing. Thus, a difference of 31 minutesbetween the predefined time frame and actual time spent was seen. This was 189% of the time aimed for. Through each test session, a trend was seen in decreasing time spent as a result of data collectors finishing assessments faster.

Overall, participants were positive towards all tests. However, regarding the ePatch, two participants experienced a temporary itch from wearing the plaster. Also, one data collector rated it lower due to having to shave chest hair of the male participants in order to fixate the plaster better.

In regard to the preventive home visit setting, the four-metre gait speed test was rated lower as to the data collector found it difficult to measure a six-metre track inside participants' homes. Also, the assessment of home hazards was done by asking the participants rather than performing the assessment independently. At the evaluation session, this was discussed. After considering the extent and potential time spent of the intended assessment, home hazards were rated low.

As for the dual-task balance test, one participant could not complete this due to feeling dizzy when standing still. Also, data collectors were positive, but they felt it was time-consuming and worried that participants would fall while performing the test. The latter was also the case for the

Table 1. Average time spent on formalities & tests and their evaluations

	Time spent (min)	Evaluations from data collectors according to setting[a]	
		Senior activity centre	Preventive home visits
Formalities			
Giving information	6.5		
Obtaining consent for participation	2.5		
Setup of participant in data capture tool	2.5		
Setting up Fysiometer hardware and software	4.5		
Tests			
Lower extremity reaction time	2	5	5
Grip strength	3	5	5
Orientation-Memory-Concentration test	3	5	5
Five times sit-to-stand	2.25	4	5
Arrhythmia screening	3	5	4
Unilateral lower extremity strength	6.25	5	3
Four-metre gait speed test	2.75	5	3
Visual acuity and contrast sensitivity	6	3	5
Dual-task balance test	4.5	3	4
Stroop test	7	3	2
Trail-making-test	9.25	1	2
Home hazards (only for preventive home visits)	1		1
In total	66		

[a]Tests receiving scores of 1–2, 3, or 4–5 were considered negative (dark grey), positive but with comments (light grey), or positive (white), respectively.

unilateral lower extremity strength test. However, no participants fell during test sessions. Pertaining to the other cognitive tests, one participant had problems distinguishing between the colours blue and green on the Stroop test colour sheet. Also, data collectors found administration of Stroop- and Trail-making-test challenging. They considered that participants did not understand test instructions and became frustrated. This resulted in longer time spent. Both the five times sit-to-stand together with measures of visual acuity and contrast sensitivity were rated lower by one data collector due to not feeling confident in administering these.

3.2. Portability

Regarding portability in general, the data collectors found this acceptable. However, circumstances where portability was complicated were mentioned, e.g. participants living on the second floor or higher with no elevator in the building.

3.3. Accommodating the test battery to the time frame

Scoring results based on individual and anonymous prioritisation in the pre-meeting survey of the five attendees to the second consensus meeting may be found in appendix 2. Table 2 shows the final prioritised list of tests. With about 16 minutes allocated for information and setting up; roughly 19 minutes remained for testing. However, data collectors' sparse experiences with all steps in the test session had to be taken into account. Therefore, testing time was extended and a cut-off at 24.5 minutes was agreed. Thus, the entire session would take 40.5 minutes to complete. This was expected to be reduced according to the 35-minute time frame as a result of further experience with giving information, setting up and testing among

Table 2. Final priority of tests based on total scores

Overall priority	Total Score	Test	Time (min)	Accumulated time (min)
1	16	Dual-task balance test	4.5	4.5
2	17	Unilateral lower extremity strength test	6.25	10.75
3	22	Lower extremity reaction time test	2	12.75
4	24	Four-metre gait speed test	2.75	15.5
4	24	Orientation-Memory-Concentration test	3	18.5
6	30	Arrhythmia-screening	3	21.5
7	33	Grip strength	3	24.5
8	34	Visual acuity & contrast sensitivity	6	30.5
9	38	Five times sit-to-stand	2.25	32.75
10	43	Stroop test	7	39.75
11	52	Home hazard evaluations	1	40.75
12	57	Trail-making-test	9.25	50

A cut-off of 24.5 minutes (solid line) was decided to accommodate the time frame. The final test battery consisted of priority 1–7.

data collectors. Thus, the final test battery included seven different fall risk factors: The dual-task balance test, measures of unilateral lower extremity strength, lower extremity reaction time and grip strength, four-metre gait speed test, Orientation-Memory-Concentration-test, and ePatch. After further discussions, all expert panel participants unanimously agreed on the final test battery.

Finally, items in the questionnaire were discussed and adjustments were made. In order to reduce the amount of questions, the Geriatric Depression Scale 15-item version was replaced with the corresponding 4-item version (D'Ath, Katona, Mullan, Evans, & Katona, 1994). Also, due to inaccurate responses,

questions on most used footwear were removed. Thus, a total of 17 fall risk factors were included in the final questionnaire.

4. Discussion

In this study, through an initial literature search and a consensus expert panel meeting, we developed a preliminary, portable, and multifactorial falls risk battery for community-dwelling older adults to fit a time frame of 35 minutes. Second, we explored its feasibility and acceptability for both the participants and the data collectors and used this information to adjust the falls risk battery to a final version, which would fit the time frame. Through this developmental process, we underestimated the time spent of the preliminary test battery by half an hour, for which reason the initial test battery was not deemed feasible. Therefore, its content was reduced from 13 to 7 tests. In addition, the content of the self-report questionnaire was reduced from 18 to 17 falls risk factors. The final test battery was feasible and acceptable for both participants and data collectors.

4.1. Research and clinical practice

With more than 400 known falls risk factors, evaluation and selection of which factors to include in a test battery is a complex task (Oliver, 2004). This was further complicated by our setting having specific requirements, i.e. acceptability and restrictions on time and weight, to address in order to enhance implementation of the test battery. Therefore, we applied consensus development methods with experts in the field and a thorough literature search combined with practical testing sessions and involvement of participants and data collectors in feasibility sessions. The advantage of this involvement became obvious as the time spent of the preliminary test battery was underestimated by an average of 31 minutes. The main component in this was found in the time allocated for formalities together with primarily the Stroop- and Trail-Making-Test. Regarding formalities, obtaining consent for participation and informing about the remaining steps in the study for the participants were substantial contributors to the extra time spent. Experiences from the data collectors suggested a higher preference among participants for information given orally and prioritised rather than written and in detail. However, both modes of information are required to achieve informed consent for participation in a research study. Thus, we recommend future studies to strive for a more balanced way of giving written and oral information to older adults.

With regard to the cognitive tests, both the data collectors and participants were frustrated over the difficulty in completing the tasks. Data collectors considered that participants did not understand the task set forth and therefore became discouraged. In addition, data collectors reported that simultaneously keeping track of time while correcting participants required excessive attention. Thus, the cognitive tests were difficult to perform on our sample and took much longer to perform than expected.

Test batteries for falls risk prediction have often been applied in a number of longitudinal studies (Hnizdo et al., 2013; Lamb et al., 2008; Obrist et al., 2016; Rodriguez-Molinero et al., 2017; Stalenhoef et al., 2002; Tromp et al., 2001; Yamashita et al., 2011). However, methods for choosing which risk factors to include in the test battery differed. Thus, prior studies have chosen risk factors based on screening recommendations from medical societies (Lamb et al., 2008), existing literature (Obrist et al., 2016), feasibility, and whether the risk factor would contribute to a multifactorial setup (Tromp et al., 2001), consensus procedures with a multidisciplinary expert panel (Stalenhoef et al., 2002), while others did not report reasons for their choices (Yamashita et al., 2011). Our study combined these techniques by using existing literature, pre- and post-test consensus procedures with a multidisciplinary expert panel in order to take feasibility and a multifactorial design into account.

4.2. Consensus methods

Due to the underestimation of the time spent, a reduction was needed in the number of falls risk factors to be tested. This adjustment in falls risk factors was done by using a modified nominal group technique (Murphy et al., 1998) to prioritise among falls risk factors based on their scientific validity, time spent, and evaluations from participants and data collectors. The modified nominal group technique was chosen to promote individual opinions equally among members of the expert panel. This makes the technique superior to informal discussions where members of the expert panel may not be sharing their views due to group dynamics (Murphy et al., 1998). Still, the informal consensus method was applied on the first consensus meeting. This was chosen since the method would generate more ideas for a preliminary test battery on the day of the meeting. By using a modified nominal group technique or a Delphi process, more time would have been required (Murphy et al., 1998). We recommend future studies to consider these aspects when consensus development is required.

4.3. Tests not included in the final test battery

The remaining tests not included in the final test battery were visual acuity, contrast sensitivity, five times sit-to-stand, and home-hazard evaluations. We chose to use a tablet-based software for the visual tests to enhance portability. This has been validated on patients with Parkinson's Disease (Lin et al., 2015) in a stationary clinical setting. Our team discussed this with the developers of the application who argued that the tablet platform is a better choice than traditional vision charts

since our testing conditions have varying lighting conditions. The tablets are backlit, so the brightness and contrast are constant with varying light intensity. Even though participants and data collectors found the tests acceptable, a lower priority was given by the expert panel due to time spent and the lack of software validation in an alternating setting with varying lighting conditions. If more time for testing was permitted, this important risk factor would have been included in the test battery based on the prioritisation in Table 2. However, it was not possible to have more time allocated for testing, due to resource limitations in the municipality. Thus, unfortunately, the incorporation of this construct was not possible. However, the Tilburg Frailty Indicator used in the self-reported questionnaire contains a question on self-perceived poor vision. Even though this is not a direct assessment of visual acuity, it may suffice for screening and prediction purposes.

The five times sit-to-stand was quick to perform. Yet, the participants should be able to rise from the chair and a floor effect has been shown in other studies thereby excluding participants with low muscle strength (Ostchega et al., 2000). This gave priority to measurements of lower extremity muscle strength using the Fysiometer setup (Blomkvist, Andersen et al., 2017). Thus, we would be able to quantify imbalance in muscle strength between the left and right leg, and also measure this parameter in future participants who cannot perform chair stands. Lastly, home hazard evaluations were excluded. Based on a recent review (Romli, Mackenzie, & Lovarini et al., 2016), the following tools were considered at the first consensus meeting: Westmead Home Safety (Clemson, Fitzgerald, & Heard, 1999), Home Falls and Accidents Screening Tool (Mackenzie, Byles, & D'Este, 2009), and Home Safety Self-Assessment Tool (Horowitz, Nochajski, & Schweitzer, 2013). However, all of these were deemed too cumbersome due to either taking too long time to complete or consisting of too many questions. Therefore, we asked the data collector to perform a short assessment of lighting conditions and whether the house was unsuitably furnished. However, this was not performed as intended and the intended assessment was also not found acceptable by the data collector, for which reason home hazard evaluations were excluded. Thus, further studies developing short and effective home hazard evaluations are needed.

It would be possible to include one or more tests in the test battery when used in a clinical assessment and not for research purposes where obtaining consent can be time consuming. In support of this, we chose to report time spent on each test. Thus, future readers, who may be interested in using the test battery, would be able to choose which tests to be used for performing clinical assessments within their corresponding time frames of their settings. However, the predictive ability of this adjusted test battery on falls would have to be investigated in a new longitudinal study before any clinical implementation.

4.4. Limitations

Our study has some limitations. First, the small and partially selected sample makes inferences to the general population difficult, but this was not the intention. We acknowledge that a larger sample size may have led to faster assessments and more positive acceptability evaluations due to increasing experience with testing. Thus, if the sample size was larger, the final test battery could possibly have included more complex tests such as the Stroop test and Trail-making-test. However, due to time trouble, we were not able to continue recruiting participants. Second, an informal consensus method was applied for the first consensus meeting. We consider this as having influenced the discussion only to a minor degree although the face-to-face contact may have restricted the discussion due to group dynamics or provided participants with additional views. Third, knowledge on medication and diagnoses could have improved the test battery but was not feasible in this set-up. Finally, the methods for evaluating participants and data collectors' experiences were not validated. The data collectors' subjective reporting of experiences from performing the tests were from alternating settings. Thus, a standardised method for evaluating this may not have detected information relevant for a successful local implementation. Regarding participants, all the tests were harmless for which reason we would assume participants rating these positively. Thus, despite the method of evaluation was not validated, we consider these useful.

5. Conclusion

Our preliminary test battery was not deemed feasible, because it exceeded the 35-minute timeframe by 31 minutes and six tests were omitted for our study population. The final test battery, which was expected to be performed within the 35-minute timeframe, consisted of four-metre gait speed test, Nintendo Wii Balance Board measures of grip strength, unilateral lower extremity strength, reaction time, and dual-task balance in addition to arrhythmia screening, and Orientation-Memory-Concentration-test. Also, a self-report questionnaire on 17 falls risk factors was composed. The questionnaire included Tilburg Frailty Indicator, Mini-Nutritional-Assessment, Vulnerable Elders Survey-13, Short Falls Efficacy Scale-International, EuroQol-5-Dimension-3-Level, Geriatric Depression Scale (4-item), and single risk factors. The final test battery was deemed feasible and acceptable to participants and data collectors. Thus, an applied feasible test battery has been developed for implementation in different settings in longitudinal studies including home assessments. Currently, we are conducting a prospective cohort study to assess the ability of the test battery to predict falls. Information on diagnoses and medication will be included in the test battery for the prospective study even though this was not included in the feasibility study for practical reasons.

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Data availability statement
Data sharing is not applicable to this article as no new data were created or analysed in this study.

Third-party material
Icons used for creating Figure 1 are publicly available at OpenClipart.org under the Creative Commons Zero 1.0 License.

Declaration of interests
MGJ was left out of the final decision at the second consensus meeting due to a potential conflict of interest in terms of him being the developer of Fysiometer. The authors report no further declaration of interests.

Trial registration
No assigning of interventions to human participants was performed and there was no evaluation of health outcomes. Thus, no trial registration was made and no TIDIer checklist, CONSORT checklist or flowchart was produced.

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